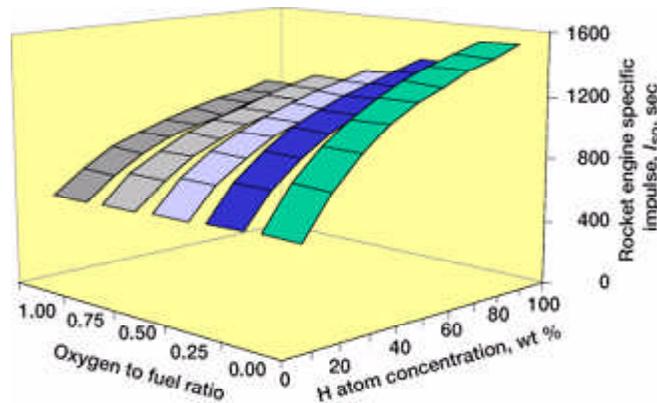


# Use of Atomic Fuels for Rocket-Powered Launch Vehicles Analyzed

At the NASA Lewis Research Center, the launch vehicle gross lift-off weight (GLOW) was analyzed for solid particle feed systems that use high-energy density atomic propellants (ref. 1). The analyses covered several propellant combinations, including atoms of aluminum, boron, carbon, and hydrogen stored in a solid cryogenic particle, with a cryogenic liquid as the carrier fluid. Several different weight percents for the liquid carrier were investigated, and the GLOW values of vehicles using the solid particle feed systems were compared with that of a conventional oxygen/hydrogen ( $O_2/H_2$ ) propellant vehicle.

Atomic propellants, such as boron, carbon, and hydrogen, have an enormous potential for high specific impulse  $I_{sp}$  operation, and their pursuit has been a topic of great interest for decades. Recent and continuing advances in the understanding of matter, the development of new technologies for simulating matter at its most basic level, and manipulations of matter through microtechnology and nanotechnology will no doubt create a bright future for atomic propellants and an exciting one for the researchers exploring this technology.

New technologies in atom isolation and in the physics of material manipulation have led to the discovery and synthesis of materials that can be used as rocket propellants (refs. 1 to 3). Solid cryogenic propellants storing atoms of aluminum, boron, carbon, or hydrogen, or other atomic additives, require a unique propulsion system design where the fuels are stored at liquid helium temperatures during ground handling and flight. Feeding atomic propellants from a propellant tank, through a feed system, to a rocket engine will be a formidable challenge.

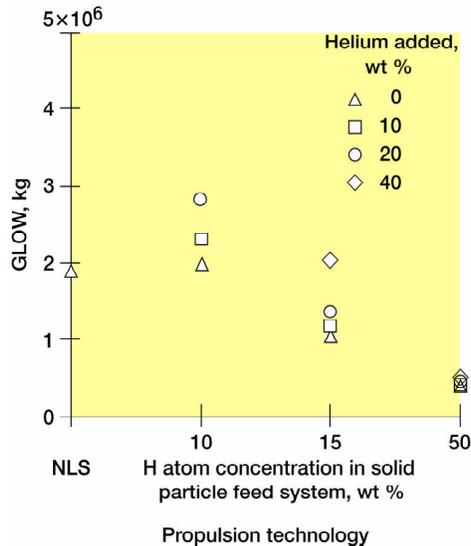


*Atomic hydrogen rocket engine performance.*

The performance with atomic H was the highest of any of the cases investigated, with its  $I_{sp}$  values ranging from 600 to nearly 1300 sec. As shown in the preceding figure, the highest monopropellant performance was 1500 sec delivered at 100 weight percent (wt %) of atomic hydrogen (H). Because it is unlikely that we will be able to store 100 wt % of atomic H, the lower levels of 10, 15, and 50 wt % were investigated in these GLOW

analyses.

The next figure illustrates the GLOW values for atomic H. With atomic H, no GLOW reductions were possible until 15 wt % of atomic H was used. At the 10-wt % level, the atomic H GLOW was 4-percent greater than the O<sub>2</sub>/H<sub>2</sub> baseline. At a 15-wt % level, the GLOW was reduced by 44 percent. With a 50-wt % atom loading, the GLOW was reduced by 78 percent.



*Comparison of atomic propellant launch vehicle gross lift-off weight (GLOW) for the National Launch System (NLS, a conventional O<sub>2</sub>/H<sub>2</sub> vehicle) and solid particle feed systems.*

When helium (He) was added to the flow with 10-wt % atomic H, the GLOW was 22- to 106-percent higher than for the baseline case, as shown in the previous figure. The 15-wt % atomic H cases only exceeded the baseline GLOW when 40-wt % He was added. For these cases, the GLOW ranged from a reduction of 37 percent (with a 10-wt % He addition) to an increase of 6 percent (with a 40-wt % He addition). The 50-wt % atomic H cases were almost unaffected by the He addition. The GLOW was 72-percent less than the O<sub>2</sub>/H<sub>2</sub> vehicle GLOW, even with the 40-wt % He addition. In summary, with atomic H at a 10-wt % level, no GLOW reductions over O<sub>2</sub>/H<sub>2</sub> vehicles were possible. At 15-wt % atomic H, there were very significant GLOW reductions for all but the 40-wt % He addition case. The 50-wt % atomic H cases showed a strong insensitivity to He addition.

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